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Stationarity of Stock Return of Nepalese Stock Market

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Abstract: *Statistical models used in stock and commodity markets typically require the assumption that the data are stationary. Stationary time series is more useful in financial economics such as volatility modelling, testing market efficiency, cointegration and causality analysis. Thus, this paper attempts to measure the stationarity of stock return series in Nepalese stock market. The most well-known stationarity tests unit root tests has been performed on the daily stock return series from Nepalese capital market over a period from February 2015 to February 2020.For this study NEPSE index, Float index ,Sensitive float and Sensitive index are used for analyses. For the stationarity test the Augmented Dickey-Fuller (ADF), Dickey Fuller- GLS (DF-GLS), Phillips Perron Kwaitkowski Phillips Schmidt-Shin (KPSS), Kwaitkowski Phillips Schmidt-Shin (KPSS) and Elloitt-Rothenberg-stock DF-GLS KPSS unit root test are employed. The tests suggest that the return series are stationarity in Nepalese capital market over thestudy period.*

Key Words: *Stock Returns, Nepse index Float index, Sensitive float index, Sensitive index, Test of Stationarity, Unit Roots.*

1. INTRODUCTION:

The study of stationarity of time series and its application has been the area of interest of researchers and academicians since last few years. Stationarity testof time series is a necessary condition for many applications of time series analysis, especially in the empirical analysis of macro-economic variables. The results obtained through econometric theory assume that thestationarity of time series as the non-stationarity of data largely invalidates standard econometric techniques. So testing for stationarity should necessarily be the first step in any time series data analysis. Stationarity of a time series provides a framework in which averaging make sense. Other properties like the mean and covariance are either fixed or evolve in a known manner, observed data cannot be averaged.

Stationarity is actually a limitation on the data creating process over time. Stationarity is a long measure in which the process creating return is identical over time. However, stationarity means that the fundamental form of the data generating process remains the same over time. This is signalised the moments of the process. It means a stationary time series has constant mean, time invariant variance, and covariance between lag values depends only on the length of the lag. In other words, mean stationarity means that the expected value of the process is constant overtime, i.e.,$E(Y_t) = \mu$; variance stationarity means that the variance is temporally stable, i.e.,; and covariance stationarity is the same, i.e., $\text{cov}(Y_t, Y_{t-s}) = \gamma_s$. In this last case, this meansthat the serial correlation of two observations (Y_t, Y_{t-s}) depends only on the lag '*s*' and not on 'where' in the series they fall.

So, a stationary time series is recognized when mean, variance, and auto-covariances are finite and constant over time. A non-stationary time series is identified by time varying mean or variance or both. The non-stationarity of data ease the empirical and communicative study of the underlying time series only for the time period under consideration. Thus non-stationarity of time series should be identified first, and then the series should be made stationary, if found non-stationary, before they are applied to empirical works.

2. LITERATURE REVIEW:

This concept of non-stationarity of time series has got wide applications in the empirical literature of financial economics. Present studies based on time series regarding to stock markets of developed and emerging capital markets. The empirical studies concerning stock markets such as testing efficient market hypothesis, performing co-integration and causality tests between leading macro-economic variables, volatility modelling, predicting stock returns and similar other studies scream for the stationarity of underlying time series. (Yule, 1926)indicated that specious correlation could purposeful in non-stationary time series.(Granger, 1974) appeared that non-stationarity lead to estimation of fake regression. (Pagan & schwert, 1990) recommends that the several non-parametric tests for covariance stationarity and applies them to common stock return data from 1834-1987. (Dickey & Fuller, 1981)observes that in recent research on the volatility of asset returns, the time series data frequently show a lack of covariance stationarity. (Groenewold, 1997)apprised the markets of Australia and New Zealand for the period of 1975-1992. The study assessed weak-form and semi-strong form efficiency in those markets and applied stationarity and autocorrelation test.The study explores the market is weak-form efficiency. But the granger causality test rejected the semi-strong form.

(Ho & Wan, 2002)recommends that nither the Asian crisis nor the 1998 currency crisis of Russia and Latin America has any significant impact on the stock return series of Australia and the US, which are found to be covariance stationary and covariance non-stationary, respectively. The survey of literature brings into forefront that the studies concerning stationarity test are lacking in Nepal.

3. DATA, METHODOLOGY AND HYPOTHESIS

Testing the stationarity of stock return of Nepalese stock market is the objective, this paper tends to examine the validity of the null hypothesis that stock return series are non-stationary in Nepalese capital market against the alternative hypothesis of stationarity. For this study NEPSE index, Float index, Sensitive float index and Sensitive index have been selected because of their undoubted representation of Nepalese stock market. On the basis of four daily indices of Nepalese stock market, the stock return series have been constructed. The daily returns using the following log return formula.

R = Ln (Pt / Pt- 1)

Where,

R = Daily return, Ln = Natural Log, Pt = Index at time t ,Pt- 1 = Index at time t-1

The sample period is taken from February 2015 to February 2020 for NEPSE index, Float index, Sensitive float index and Sensitive index based stock return series and from February 2015 to February 2020. All the data have been collected from the official website of NEPSE. This paper used the Augmented Dickey-Fuller (ADF), Dickey Fuller- GLS(DF-GLS), Phillips Perron Kwaitkowski Phillips Schmidt-Shin(KPSS), Kwaitkowski Phillips Schmidt-Shin(KPSS) and Elloitt-Rothenberg-stock DF-GLS KPSS unit root test as the test of stationarity of time series. These statistical tests are discussed more closely in each following with the help of Eviews.

3.1. Hypothesis:

H0: Stock return series are non-stationary.
H1: Stock return series are stationary.

4. EMPIRICAL RESULTS:

The null hypothesis of the study that the daily stock return series in Nepalese capital market are non-stationary have been tested through Unit root test(Augmented Dickey Fuller(ADF), Dickey Fuller- GLS(DF-GLS), Phillips Perron, Kwaitkowski Phillips Schmidt-Shin(KPSS) and Elloitt-Rothenberg-stock DF-GLS) for the four indices based stock return series consisting of 1164 sample units. The results of unit root test are given in Table-1, Table-2,Table-3 and Table-4. The results of unit root tests of NEPSE index are given in Table-1 indicates the null hypothesis is rejected due to the higher statistical value than critical value at 5% level of significance. The results of unit root tests of three indices are summarized in Table-2 to Table-4. All the unit root results except KPSS reject the null hypothesis because test statistics are more than critical values. Thus, the series are stationary. In other words, the stock return series in Nepalese capital market are stationary and price can be predicted.

Table-1. Unit root test of NEPSE index

Tests	Statistical value	Critical value@5%
Augmented Dickey Fuller(ADF)	-17.64718	-2.863840
Dickey Fuller- GLS(DF-GLS)	-17.65445	-1.941098
Phillips Perron	-1184.111	-2.863818
Kwaitkowski Phillips Schmidt-Shin(KPSS)	0.50000	0.463000
Elloitt-Rothenberg-stock DF-GLS	23.80752	3.260000

Table-2. Unit root test of Float index

Test	Statistical value	Critical value@5%
Augmented Dickey Fuller(ADF)	-19.53913	-2.863829
Dickey Fuller- GLS(DF-GLS)	-19.25412	-1.941097
Phillips Perron	-236.8818	-2.863810
Kwaitkowski Phillips Schmidt-Shin(KPSS)	0.032188	0.463000
Elloitt-Rothenberg-stock DF-GLS	13.07461	3.260000

Table-3. Unit root test of Sensitive float index

Test	Statistical value	Critical value@5%
Augmented Dickey Fuller(ADF)	-19.34789	-2.863829
Dickey Fuller- GLS(DF-GLS)	-19.82098	-1.941096
Phillips Perron	-219.2232	-2.863810
Kwaitkowski Phillips Schmidt-Shin(KPSS)	0.031193	0.463000
Elloitt-Rothenberg-stock DF-GLS	12.06823	3.260000

Table-4. Unit root test of Sensitive index

Test	Statistical value	Critical value@5%
Augmented Dickey Fuller(ADF)	-19.43138	-2.863829
Dickey Fuller- GLS(DF-GLS)	-24.44919	-1.941096
Phillips Perron	-212.1671	-2.863810
Kwaitkowski Phillips Schmidt-Shin(KPSS)	0.024844	0.463000
Elloitt-Rothenberg-stock DF-GLS	12.32812	3.260000

5. CONCLUSION:

This paper examines the stationarity of daily stock return series in Nepalese capital market selecting four stock price indices, namely, NEPSE index, Float index, Sensitive float index and Sensitive over the period spanning from February2015 to February 2020. The paper by performing different unit root tests adds to the literature the evidence of stationarity of daily stock return series in Nepalese capital market. The result is useful for modelling the market volatility, testing for market efficiency, cointegration and causality using the underlying time series. The stationary time series has three important properties. First, it has a definable mean which suggests that a stationary series fluctuates around a constant long-run mean. Second, a stationary time series has a definable variance. Third, a stationary time series data set has finite auto-covariance. The covariance or weak stationarity of daily stock return data classifies the Nepalese capital market as weak form inefficient as per Efficient Market Hypothesis.

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Appendices
NEPSE

Appendix-1

Null Hypothesis: D(R1) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.64718	0.0000
Test critical values:	1% level	-3.435811	
	5% level	-2.863840	
	10% level	-2.568045	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(R1,2)
Method: Least Squares
Date: 10/23/20 Time: 08:41

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Sample (adjusted): 13 1164
Included observations: 1152 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R1(-1))	-6.552724	0.371318	-17.64718	0.0000
D(R1(-1),2)	4.626473	0.358069	12.92063	0.0000
D(R1(-2),2)	3.784436	0.334901	11.30018	0.0000
D(R1(-3),2)	3.026806	0.304339	9.945516	0.0000
D(R1(-4),2)	2.353543	0.268378	8.769511	0.0000
D(R1(-5),2)	1.764635	0.228717	7.715358	0.0000
D(R1(-6),2)	1.259857	0.186903	6.740702	0.0000
D(R1(-7),2)	0.839559	0.144421	5.813279	0.0000
D(R1(-8),2)	0.503473	0.102812	4.897014	0.0000
D(R1(-9),2)	0.251405	0.063800	3.940543	0.0001
D(R1(-10),2)	0.083569	0.029514	2.831526	0.0047
C	3.66E-06	0.091671	4.00E-05	1.0000

R-squared	0.821752	Mean dependent var	-1.11E-05
Adjusted R-squared	0.820032	S.D. dependent var	7.334366
S.E. of regression	3.111432	Akaike info criterion	5.118405
Sum squared resid	11036.35	Schwarz criterion	5.171002
Log likelihood	-2936.202	Hannan-Quinn criter.	5.138258
F-statistic	477.7798	Durbin-Watson stat	2.012941
Prob(F-statistic)	0.000000		

Appendix-2

Null Hypothesis: D(R1) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on SIC, maxlag=22)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-17.65445
Test critical values:	1% level	-2.566971
	5% level	-1.941098
	10% level	-1.616514

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 10/23/20 Time: 08:42
Sample (adjusted): 13 1164
Included observations: 1152 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-6.552452	0.371150	-17.65445	0.0000
D(GLSRESID(-1))	4.626212	0.357906	12.92576	0.0000
D(GLSRESID(-2))	3.784194	0.334749	11.30457	0.0000
D(GLSRESID(-3))	3.026589	0.304201	9.949303	0.0000
D(GLSRESID(-4))	2.353356	0.268257	8.772775	0.0000
D(GLSRESID(-5))	1.764482	0.228614	7.718161	0.0000
D(GLSRESID(-6))	1.259738	0.186819	6.743089	0.0000
D(GLSRESID(-7))	0.839473	0.144356	5.815281	0.0000
D(GLSRESID(-8))	0.503417	0.102767	4.898652	0.0000
D(GLSRESID(-9))	0.251376	0.063772	3.941819	0.0001
D(GLSRESID(-10))	0.083559	0.029501	2.832412	0.0047

R-squared	0.821750	Mean dependent var	-1.11E-05
Adjusted R-squared	0.820188	S.D. dependent var	7.334366
S.E. of regression	3.110086	Akaike info criterion	5.116681
Sum squared resid	11036.48	Schwarz criterion	5.164894
Log likelihood	-2936.208	Hannan-Quinn criter.	5.134879
Durbin-Watson stat	2.012937		

Appendix-3

Null Hypothesis: D(R1) has a unit root
Exogenous: Constant
Bandwidth: 1.16e+003 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1184.111	1.0000
Test critical values:	1% level	-3.435763	
	5% level	-2.863818	
	10% level	-2.568033	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	13.19234
HAC corrected variance (Bartlett kernel)	0.018784

Phillips-Perron Test Equation
Dependent Variable: D(R1,2)
Method: Least Squares
Date: 10/23/20 Time: 08:43
Sample (adjusted): 3 1164
Included observations: 1162 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R1(-1))	-1.504826	0.025345	-59.37362	0.0000
C	1.36E-05	0.106643	0.000128	0.9999

R-squared	0.752413	Mean dependent var	-6.79E-06
Adjusted R-squared	0.752200	S.D. dependent var	7.302711
S.E. of regression	3.635256	Akaike info criterion	5.420956
Sum squared resid	15329.50	Schwarz criterion	5.429661
Log likelihood	-3147.575	Hannan-Quinn criter.	5.424240
F-statistic	3525.226	Durbin-Watson stat	2.338838
Prob(F-statistic)	0.000000		

Appendix-4

Null Hypothesis: D(R1) is stationary
Exogenous: Constant
Bandwidth: 1.16e+003 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.500000
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	17.68904
HAC corrected variance (Bartlett kernel)	0.015062

KPSS Test Equation
Dependent Variable: D(R1)
Method: Least Squares
Date: 10/23/20 Time: 08:43
Sample (adjusted): 2 1164
Included observations: 1163 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.40E-06	0.123381	4.37E-05	1.0000

R-squared	0.000000	Mean dependent var	5.40E-06
Adjusted R-squared	0.000000	S.D. dependent var	4.207644
S.E. of regression	4.207644	Akaike info criterion	5.712542
Sum squared resid	20572.36	Schwarz criterion	5.716892
Log likelihood	-3320.843	Hannan-Quinn criter.	5.714183
Durbin-Watson stat	3.009653		

Appendix-5

Null Hypothesis: D(R1) has a unit root
Exogenous: Constant
Lag length: 10 (Spectral OLS AR based on SIC, maxlag=22)
Sample (adjusted): 2 1164
Included observations: 1163 after adjustments

		P-Statistic
Elliott-Rothenberg-Stock test statistic		23.80752
Test critical values:	1% level	1.990000
	5% level	3.260000
	10% level	4.480000

*Elliott-Rothenberg-Stock (1996, Table 1)

HAC corrected variance (Spectral OLS autoregression)	0.031305

Float index

Appendix-6

Null Hypothesis: D(R2) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.53913	0.0000
Test critical values:	1% level	-3.435787	
	5% level	-2.863829	
	10% level	-2.568039	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(R2,2)
Method: Least Squares
Date: 10/23/20 Time: 08:47
Sample (adjusted): 12 1168
Included observations: 1157 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R2(-1))	-5.437877	0.278307	-19.53913	0.0000
D(R2(-1),2)	3.742394	0.264624	14.14231	0.0000
D(R2(-2),2)	3.057451	0.244282	12.51607	0.0000
D(R2(-3),2)	2.427500	0.218320	11.11901	0.0000
D(R2(-4),2)	1.868790	0.188730	9.901934	0.0000
D(R2(-5),2)	1.392186	0.156145	8.915964	0.0000
D(R2(-6),2)	0.998930	0.122221	8.173159	0.0000
D(R2(-7),2)	0.628682	0.088802	7.079562	0.0000
D(R2(-8),2)	0.352174	0.057215	6.155288	0.0000
D(R2(-9),2)	0.126471	0.029336	4.311098	0.0000
C	4.97E-06	0.000347	0.014344	0.9886

R-squared	0.761916	Mean dependent var	-1.51E-05
Adjusted R-squared	0.759839	S.D. dependent var	0.024073

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S.E. of regression	0.011797	Akaike info criterion	-6.032406
Sum squared resid	0.159500	Schwarz criterion	-5.984360
Log likelihood	3500.747	Hannan-Quinn criter.	-6.014275
F-statistic	366.7435	Durbin-Watson stat	2.015827
Prob(F-statistic)	0.000000		

Appendix-7

Null Hypothesis: D(R2) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on SIC, maxlag=22)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-19.25412
Test critical values:	1% level	-2.566962
	5% level	-1.941097
	10% level	-1.616515

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 10/23/20 Time: 08:47
Sample (adjusted): 12 1168
Included observations: 1157 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-5.316175	0.276106	-19.25412	0.0000
D(GLSRESID(-1))	3.627211	0.262558	13.81487	0.0000
D(GLSRESID(-2))	2.952420	0.242441	12.17787	0.0000
D(GLSRESID(-3))	2.335690	0.216778	10.77457	0.0000
D(GLSRESID(-4))	1.792161	0.187530	9.556644	0.0000
D(GLSRESID(-5))	1.331878	0.155297	8.576320	0.0000
D(GLSRESID(-6))	0.954908	0.121697	7.846629	0.0000
D(GLSRESID(-7))	0.599598	0.088539	6.772155	0.0000
D(GLSRESID(-8))	0.335936	0.057135	5.879721	0.0000
D(GLSRESID(-9))	0.120070	0.029352	4.090722	0.0000

R-squared	0.760130	Mean dependent var	-1.51E-05
Adjusted R-squared	0.758248	S.D. dependent var	0.024073
S.E. of regression	0.011836	Akaike info criterion	-6.026658
Sum squared resid	0.160697	Schwarz criterion	-5.982980
Log likelihood	3496.422	Hannan-Quinn criter.	-6.010176
Durbin-Watson stat	2.013061		

Appendix-8

Null Hypothesis: D(R2) has a unit root
Exogenous: Constant
Bandwidth: 92 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-236.8818	0.0001
Test critical values:	1% level	-3.435743	
	5% level	-2.863810	
	10% level	-2.568029	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000185
HAC corrected variance (Bartlett kernel)	3.83E-06

Phillips-Perron Test Equation
Dependent Variable: D(R2,2)
Method: Least Squares
Date: 10/23/20 Time: 08:48
Sample (adjusted): 3 1168
Included observations: 1166 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R2(-1))	-1.359523	0.027359	-49.69144	0.0000
C	1.14E-05	0.000399	0.028508	0.9773

R-squared	0.679625	Mean dependent var	-1.02E-05
Adjusted R-squared	0.679350	S.D. dependent var	0.024042
S.E. of regression	0.013614	Akaike info criterion	-5.753738
Sum squared resid	0.215734	Schwarz criterion	-5.745056
Log likelihood	3356.429	Hannan-Quinn criter.	-5.750463
F-statistic	2469.240	Durbin-Watson stat	2.211961
Prob(F-statistic)	0.000000		

Appendix-9

Null Hypothesis: D(R2) is stationary
Exogenous: Constant
Bandwidth: 69 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.032188
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.000212
HAC corrected variance (Bartlett kernel)	3.84E-06

KPSS Test Equation
Dependent Variable: D(R2)
Method: Least Squares
Date: 10/23/20 Time: 08:48
Sample (adjusted): 2 1168
Included observations: 1167 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.89E-06	0.000427	0.013802	0.9890

R-squared	0.000000	Mean dependent var	5.89E-06
Adjusted R-squared	0.000000	S.D. dependent var	0.014576
S.E. of regression	0.014576	Akaike info criterion	-5.617985
Sum squared resid	0.247738	Schwarz criterion	-5.613647
Log likelihood	3279.094	Hannan-Quinn criter.	-5.616349
Durbin-Watson stat	2.718106		

Appendix-10

Null Hypothesis: D(R2) has a unit root
Exogenous: Constant
Lag length: 9 (Spectral OLS AR based on SIC, maxlag=22)
Sample (adjusted): 2 1168
Included observations: 1167 after adjustments

		P-Statistic
Elliott-Rothenberg-Stock test statistic		13.07461
Test critical values:	1% level	1.990000
	5% level	3.260000
	10% level	4.480000

*Elliott-Rothenberg-Stock (1996, Table 1)

HAC corrected variance (Spectral OLS autoregression)	7.46E-07

Sensitive float
Appendix-11

Null Hypothesis: D(R3) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.34789	0.0000
Test critical values:	1% level	-3.435787	
	5% level	-2.863829	
	10% level	-2.568039	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(R3,2)
Method: Least Squares
Date: 10/23/20 Time: 08:50
Sample (adjusted): 12 1168
Included observations: 1157 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R3(-1))	-5.242658	0.270968	-19.34789	0.0000
D(R3(-1),2)	3.571712	0.257369	13.87779	0.0000
D(R3(-2),2)	2.917589	0.237588	12.28003	0.0000
D(R3(-3),2)	2.306975	0.212547	10.85395	0.0000
D(R3(-4),2)	1.785556	0.183915	9.708578	0.0000
D(R3(-5),2)	1.328314	0.152451	8.713067	0.0000
D(R3(-6),2)	0.959563	0.119736	8.014010	0.0000
D(R3(-7),2)	0.611418	0.087223	7.009803	0.0000
D(R3(-8),2)	0.346497	0.056627	6.118953	0.0000
D(R3(-9),2)	0.120255	0.029364	4.095318	0.0000
C	6.18E-06	0.000355	0.017414	0.9861

R-squared	0.755411	Mean dependent var	-1.84E-05
Adjusted R-squared	0.753277	S.D. dependent var	0.024286
S.E. of regression	0.012063	Akaike info criterion	-5.987841
Sum squared resid	0.166769	Schwarz criterion	-5.939795
Log likelihood	3474.966	Hannan-Quinn criter.	-5.969710
F-statistic	353.9413	Durbin-Watson stat	2.017281
Prob(F-statistic)	0.000000		

Appendix-12

Null Hypothesis: D(R3) has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on SIC, maxlag=22)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-19.82098
Test critical values:	1% level	-2.566957
	5% level	-1.941096
	10% level	-1.616516

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 10/23/20 Time: 08:51
Sample (adjusted): 9 1168
Included observations: 1160 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-3.324496	0.167726	-19.82098	0.0000
D(GLSRESID(-1))	1.733744	0.154135	11.24823	0.0000
D(GLSRESID(-2))	1.204209	0.134004	8.986336	0.0000
D(GLSRESID(-3))	0.758088	0.109431	6.927528	0.0000
D(GLSRESID(-4))	0.436304	0.082209	5.307242	0.0000
D(GLSRESID(-5))	0.211074	0.054963	3.840285	0.0001
D(GLSRESID(-6))	0.092406	0.029352	3.148243	0.0017

R-squared	0.733304	Mean dependent var	-5.48E-06
Adjusted R-squared	0.731916	S.D. dependent var	0.024288
S.E. of regression	0.012576	Akaike info criterion	-5.908115
Sum squared resid	0.182339	Schwarz criterion	-5.877604
Log likelihood	3433.707	Hannan-Quinn criter.	-5.896603
Durbin-Watson stat	2.007583		

Appendix-13

Null Hypothesis: D(R3) has a unit root
Exogenous: Constant
Bandwidth: 89 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-219.2232	0.0001
Test critical values:	1% level	-3.435743	
	5% level	-2.863810	
	10% level	-2.568029	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000191
HAC corrected variance (Bartlett kernel)	4.47E-06

Phillips-Perron Test Equation
Dependent Variable: D(R3,2)
Method: Least Squares
Date: 10/23/20 Time: 08:52
Sample (adjusted): 3 1168
Included observations: 1166 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R3(-1))	-1.350420	0.027463	-49.17196	0.0000
C	1.26E-05	0.000405	0.031209	0.9751

R-squared	0.675031	Mean dependent var	-1.23E-05
Adjusted R-squared	0.674752	S.D. dependent var	0.024257
S.E. of regression	0.013834	Akaike info criterion	-5.721669
Sum squared resid	0.222764	Schwarz criterion	-5.712988
Log likelihood	3337.733	Hannan-Quinn criter.	-5.718394
F-statistic	2417.881	Durbin-Watson stat	2.197175
Prob(F-statistic)	0.000000		

Appendix-14

Null Hypothesis: D(R3) is stationary
Exogenous: Constant
Bandwidth: 68 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.031193
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.000218
HAC corrected variance (Bartlett kernel)	4.29E-06

KPSS Test Equation
Dependent Variable: D(R3)
Method: Least Squares
Date: 10/23/20 Time: 08:52
Sample (adjusted): 2 1168
Included observations: 1167 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.89E-06	0.000432	0.015945	0.9873

R-squared	0.000000	Mean dependent var	6.89E-06
Adjusted R-squared	0.000000	S.D. dependent var	0.014757
S.E. of regression	0.014757	Akaike info criterion	-5.593327
Sum squared resid	0.253923	Schwarz criterion	-5.588989
Log likelihood	3264.706	Hannan-Quinn criter.	-5.591690
Durbin-Watson stat	2.699617		

Appendix-15

Null Hypothesis: D(R3) has a unit root
Exogenous: Constant
Lag length: 9 (Spectral OLS AR based on SIC, maxlag=22)
Sample (adjusted): 2 1168
Included observations: 1167 after adjustments

		P-Statistic
Elliott-Rothenberg-Stock test statistic		12.06823
Test critical values:	1% level	1.990000
	5% level	3.260000
	10% level	4.480000

*Elliott-Rothenberg-Stock (1996, Table 1)

HAC corrected variance (Spectral OLS autoregression)	8.60E-07

Sensitive index
Appendix-16

Null Hypothesis: D(R4) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-19.43138	0.0000
Test critical values:	1% level	-3.435787	
	5% level	-2.863829	
	10% level	-2.568039	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(R4,2)
Method: Least Squares
Date: 10/23/20 Time: 08:54
Sample (adjusted): 12 1168
Included observations: 1157 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R4(-1))	-5.313217	0.273435	-19.43138	0.0000
D(R4(-1),2)	3.629890	0.259797	13.97201	0.0000
D(R4(-2),2)	2.962326	0.239869	12.34976	0.0000
D(R4(-3),2)	2.349728	0.214581	10.95032	0.0000
D(R4(-4),2)	1.815945	0.185734	9.777106	0.0000
D(R4(-5),2)	1.350173	0.153841	8.776400	0.0000
D(R4(-6),2)	0.981911	0.120685	8.136156	0.0000
D(R4(-7),2)	0.627322	0.087908	7.136126	0.0000
D(R4(-8),2)	0.355244	0.056891	6.244237	0.0000
D(R4(-9),2)	0.122890	0.029350	4.187097	0.0000
C	3.76E-06	0.000335	0.011217	0.9911

R-squared	0.759123	Mean dependent var	-1.66E-05
Adjusted R-squared	0.757021	S.D. dependent var	0.023106
S.E. of regression	0.011390	Akaike info criterion	-6.102739
Sum squared resid	0.148667	Schwarz criterion	-6.054692
Log likelihood	3541.434	Hannan-Quinn criter.	-6.084607
F-statistic	361.1615	Durbin-Watson stat	2.015640
Prob(F-statistic)	0.000000		

Appendix-17

Null Hypothesis: D(R4) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=22)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-24.44919
Test critical values:	1% level	-2.566954
	5% level	-1.941096
	10% level	-1.616516

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 10/23/20 Time: 08:55
Sample (adjusted): 7 1168
Included observations: 1162 after adjustments

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Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-2.815682	0.115165	-24.44919	0.0000
D(GLSRESID(-1))	1.241304	0.099447	12.48212	0.0000
D(GLSRESID(-2))	0.750781	0.077952	9.631279	0.0000
D(GLSRESID(-3))	0.376448	0.053618	7.020929	0.0000
D(GLSRESID(-4))	0.132071	0.029154	4.530142	0.0000

R-squared	0.729450	Mean dependent var	-1.43E-05
Adjusted R-squared	0.728514	S.D. dependent var	0.023094
S.E. of regression	0.012033	Akaike info criterion	-5.998029
Sum squared resid	0.167526	Schwarz criterion	-5.976265
Log likelihood	3489.855	Hannan-Quinn criter.	-5.989818
Durbin-Watson stat	2.010462		

Appendix-18

Null Hypothesis: D(R4) has a unit root
Exogenous: Constant
Bandwidth: 74 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-212.1671	0.0001
Test critical values:	1% level	-3.435743	
	5% level	-2.863810	
	10% level	-2.568029	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000171
HAC corrected variance (Bartlett kernel)	4.39E-06

Phillips-Perron Test Equation
Dependent Variable: D(R4,2)
Method: Least Squares
Date: 10/23/20 Time: 08:55
Sample (adjusted): 3 1168
Included observations: 1166 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R4(-1))	-1.356561	0.027395	-49.51862	0.0000
C	9.55E-06	0.000384	0.024885	0.9802

R-squared	0.678106	Mean dependent var	-1.02E-05
Adjusted R-squared	0.677829	S.D. dependent var	0.023081
S.E. of regression	0.013101	Akaike info criterion	-5.830547
Sum squared resid	0.199784	Schwarz criterion	-5.821865
Log likelihood	3401.209	Hannan-Quinn criter.	-5.827272
F-statistic	2452.093	Durbin-Watson stat	2.206778
Prob(F-statistic)	0.000000		

Appendix-19

Null Hypothesis: D(R4) is stationary
Exogenous: Constant
Bandwidth: 55 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.024844
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.000196
HAC corrected variance (Bartlett kernel)	4.59E-06

KPSS Test Equation
Dependent Variable: D(R4)
Method: Least Squares
Date: 10/23/20 Time: 08:56
Sample (adjusted): 2 1168
Included observations: 1167 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.66E-06	0.000410	0.008923	0.9929

R-squared	0.000000	Mean dependent var	3.66E-06
Adjusted R-squared	0.000000	S.D. dependent var	0.014010
S.E. of regression	0.014010	Akaike info criterion	-5.697244
Sum squared resid	0.228860	Schwarz criterion	-5.692907
Log likelihood	3325.342	Hannan-Quinn criter.	-5.695608
Durbin-Watson stat	2.711917		

Appendix-20

Null Hypothesis: D(R4) has a unit root
Exogenous: Constant
Lag length: 9 (Spectral OLS AR based on SIC, maxlag=22)
Sample (adjusted): 2 1168
Included observations: 1167 after adjustments

		P-Statistic
Elliott-Rothenberg-Stock test statistic		12.32812
Test critical values:	1% level	1.990000
	5% level	3.260000
	10% level	4.480000

*Elliott-Rothenberg-Stock (1996, Table 1)

HAC corrected variance (Spectral OLS autoregression)	7.38E-07